

USER'S MANUAL

MODEL: 5971-160 Current Reversal Switch



PROPRIETARY

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Section 1

WARNINGS

REFER TO WARNINGS BELOW BEFORE OPERATING THE 5971-160 REVERSAL SWITCH

2.1 - Personal Safety

Never service alone. Do not perform service to the 5971-160 Reversal Switch and associated DC Power Supply unless another person is present who is capable of rendering first aid.

The output from the model 5971-160 Reversal Switch and its DC Power Supply is potentially lethal. It is capable of delivering high voltages at high current. Do not remove protective covers or leave cable terminations exposed. Do not operate if terminals or cables are damaged.

2.2 - Current Connections

Special care should be taken to insure that the current terminations are secure and do not work loose in operation. Local heating at the terminations can cause rapid oxidation leading to a high contact resistance and high power dissipation at the terminals. If left unchecked this can cause enough local heating to damage or destroy the current connection terminals.

2.3 - Interlocks

The 5971-160 Reversal Switch has interlock connections between the DC Power Supply and the Electromagnet load. The interlocks must be connected for proper system functioning and protection of the equipment, facility and to protect against personal injury. Attempting to operate the system with the interlocks defeated is not recommended and will void the warranty.

Section 2

SPECIFICATIONS

Table 1. Model 5971-160 Current Reversal Switch Specifications

Electrical	
Power Input (From DC Supply)	160A maximum
Recommended DC Power Supplies	Sorensen DLM40-75E Sorensen SGA 60/83 60V, 83A Sorensen SGA 100/150 100V, 150A Sorensen SGA 160/31 160V, 31A Sorensen SGA 160/62 160V, 62A Sorensen SGA 160/156 160V, 156A Sorensen SGA 200/75 200V, 75A
Power Input (Aux Power Supply)	115-220VAC, 50/60Hz, 2A
Note: While the power input module has a ‘selectable’ voltage range, it is not necessary to select the range for any voltage between 115 - 220VAC.	
Power Output	200V, 160A maximum
Switch Voltage Drop (at 20°C)	< 440mV at 150A
Switch Resistance at 150A (at 20°C)	< 3mΩ
Control Modes	
Computer Control	National Instruments Multifunction DAQ, Model USB-6251 Current Control Resolution: 16 bits Current & Voltage Monitor Resolution: 16 bits Digital read back of amplifier and magnet interlock status Magnetic field read back resolution: 16 bits
Manual Control	Manual control of the DC current via the DC Power Supply’s front panel controls Manual control of the current polarity via the Current Reversal Switch’s front panel controls
Computer Control with external Analog Current Programming Input	National Instruments Multifunction DAQ, Model USB-6251 Current & Voltage Monitor Resolution: 16 bits Digital read back of amplifier and magnet interlock status Magnetic field read back resolution: 16 bits User provided 0 - 10 volt analog control
Current Control Programming Voltage⁽¹⁾	0 - 10 volt analog

Note (1): The Current output control may be via either the USB interface or the external analog input, but not both.

Mechanical

5971-160 Current Reversal Switch

Form Factor	2U rack mount fully enclosed chassis
Overall Dimensions	482mm (19") wide x 88.1mm (3.5") high x 507mm (20") deep
Weight	15.75 kg (35lbs)

5971-160 Current Reversal Switch & SGA Power Supply in Optima Rack

Overall Dimensions	560.5 (22") wide x 1,058 (41.6") high x 823 (32.4") deep
Weight (with Sorensen SGA 60/83)	105.75kg (235lbs)
Weight (with Sorensen SGA 100/150)	115kg (250lbs)

Section 3

INSTALLATION

Caution: In many cases, the Reversal Switch and DC Power Supply will be pre-installed by GMW into a 19" EIA equipment rack. If it is not, care should be taken during rack mounting to avoid personal injury or damage to the equipment.

3.1 - Unpacking Instructions and Damage Inspection

3.1.1 - Systems Shipped with a GMW Supplied Rack:

1. Remove all eight of the lag bolts located at the lower edge of all the side panels of the crate top cover.
2. Gently rock the crate top cover to work it loose from the shipping crate base.
3. Use one person on each side of the shipping crate grip the side panels of the crate top cover. Lift the crate top cover high enough to clear top of the rack, walk the cover sideways to a clear area and place it upon the floor.
4. Inspect the rack and its contents to ensure that no damage has occurred during shipment. If any damage is evident report the damage in detail to the shipper for claim and simultaneously notify GMW in case an assessment of the damage must be made. If no damage is found, proceed with the unpacking and installation.
5. Cut the straps that secure the rack to the pallet base.
6. Remove the wood block at the bottom front edge of the rack.
7. Carefully slide the rack forward and off of the pallet base.
8. Unpack any other system components as per their instruction manuals.

3.1.2 - Systems Shipped without a GMW Supplied Rack:

1. Open the outer shipping carton by cutting the packing tape along the joints.
2. Remove the inner shipping carton by carefully lifting it out.
3. Open the inner shipping carton by cutting the packing tape along the joints.
4. Carefully lift the reversal switch clear of the shipping carton.
5. Inspect the reversal switch for any damage.
6. Retain all packing materials for future shipping needs.

3.2 - Rack Mounting

When rack mounting the 5971-160 Reversal Switch it is important to note that the vertical mounting flanges alone are not strong enough to support the weight of the Reversal Switch. Support angles on each side, beneath the 5971-160, must also be used. Failure to use adequate support angles will result in equipment damage.

Take care when selecting a rack that it has enough depth to completely house the Reversal Switch and DC Supply. The RC-351930 Bench Height Rack offered by GMW has an internal depth of 762mm (30"). Typical installations would put the DC Supply at the bottom of the rack, with the Reversal Switch just above, thus keeping the center of gravity as low as possible in the rack. Other instrumentation may then be installed in to the upper sections of the rack.

Note: Telco style racks are NOT appropriate for the Reversal Switch and DC Supply.

3.3 - Electrical Connections

Even if the 5971-160 Reversal Switch was ordered as a complete system and assembled into a rack by GMW, it is still recommended to follow and verify the following section as connections may have loosened during shipment.

Refer to drawing 13907-0009-0, Rev. A for a detailed connection diagram.

3.3.1 - DC Supply and Electromagnet Connections

1. Connect the DC Supply to Switch Cable to the input +, input – and ground. This cable provides the DC power, ground and interlock signals between the DC Power Supply and the Switch. Ensure that ALL connections are tight, the polarity is correct and the interlock cable is properly connected.
2. Connect the Reversal Switch to Electromagnet Cable output +, output – and ground. This cable provides the current, ground and interlock signals between the Switch and the Electromagnet. Again ensure that ALL connections are tight, the polarity is correct and the interlock cable is properly connected.

It is critical that the DC Supply to the Reversal Switch and the Reversal Switch to Electromagnet cables are connected correctly to the Reversal Switch Rear Panel terminals. Incorrect connection may cause damage to the DC Power Supply or the Reversal Switch.

3.3.2 – Reversal Switch Power

Connect the 115Vac or 220Vac power cord to the Reversal Switch. - This provides the Reversal Switch with its required auxiliary power for the interlocks, computer interface, magnetic field sensor and cooling fans.

3.3.1 - DC Supply Main Power

This procedure should be carried out by a qualified electrician.

1. Connect the DC Supply to the AC Mains service via an appropriate three-phase AC power disconnect / breaker panel. For a GMW supported power supply, the maximum input currents per phase are given below.

DC Power Supply	Voltage	Phases	Current per Phase
DLM40-75E, 3kW	180-264V	3	16A
SGA 60/83, 5kW	187-242V	3	21A
SGA 100/150, 15kW	187-242V	3	62A
SGA 160/156, 25kW	187-242V	3	103A

2. Ensure that the Electromagnet, Reversal Switch and DC Power Supply grounds are connected. The DC Power Supply must be connected to the local service ground.

Section 4

SYSTEM DESCRIPTION

4.1 - System Description

A complete system would typically consist of an appropriate SGA series DC power supply, the GMW 5971-160 Reversal Switch, a Senis magnetic field transducer, an electromagnet and an appropriate computer and software or an external analog programming signal.

The DC Supply provides current to the electromagnet via the Reversal Switch, and is safety interlocked by means of a relay contact in the Reversal Switch. The Supply's output is enabled on a closed contact, providing protection should the interlock cable be disconnected. Two conditions will cause the interlock relay to open, shutting down the DC Supply's output: An internal fault detected in the Reversal Switch or a failure in the temperature or water flow interlocks on the electromagnet.

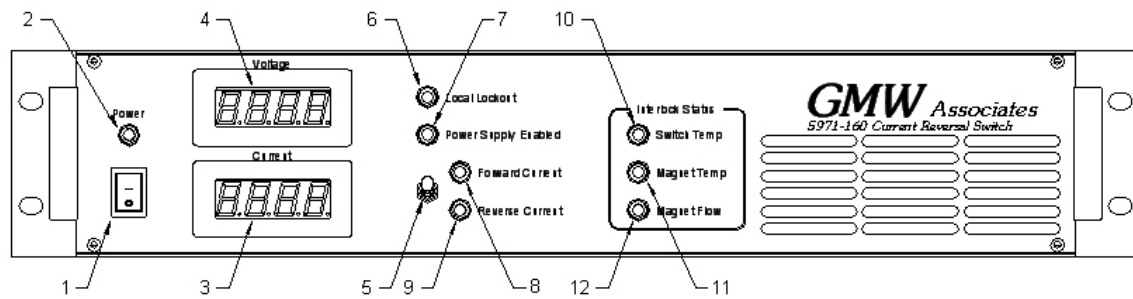
The 5971-160 Current Reversal Switch is comprised of several sections: A proprietary MOSFET switch and associated control electronics, a National Instruments USB-6251 Control with USB interface and an auxiliary power supply all integrated into a single 19" rack mounting chassis. Refer to drawing no. 13907-0008-0, Rev. A for an internal block diagram.

The auxiliary power supply provides power for the cooling fans, interlocks, control circuitry and interface. It also provides -12V and +12V (400mA each) on the rear panel for an optional external Senis Magnetic Field Transducer for magnetic field measurement and closed-loop field control.

The interlock circuit for the magnet requires a 'closed contact' connection. Provision for both the magnet over temperature and water flow is provided, and a failure of either one is indicated on the front panel of the Reversal Switch. When using the NI USB-6251 DAQ, this information is available via the computer control software. In the event of a magnet interlock fault, the output of the DC Supply is inhibited.

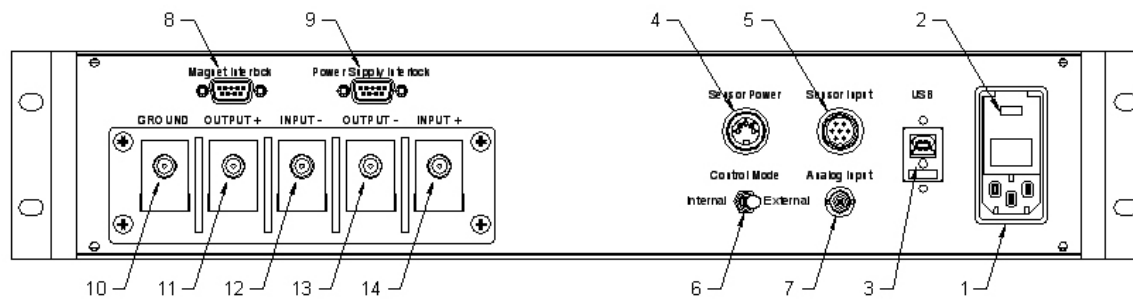
The NI USB-6251 DAQ interface provides computer control and monitoring of the system. It uses a 16-bit analog output ($\pm 10V$) to provide the programming signal to the DC Supply. The output voltage and current are monitored by two 16-bit input channels. Complete Reversal switch and magnet interlock status is also monitored via its digital input channels. When using an optional Senis Magnetic Field Transducer, the field is read back on a third 16-bit analog channel. For more information, please refer to the NI USB-6251 Manual and section 4.5 in this manual.

4.1.1 - Front Panel



1. Power Switch
2. Power Indicator
3. Output Current Display
4. Output Voltage Display
5. Manual Current Polarity Control
6. Local Lockout Indicator
7. Power Supply Enabled Indicator
8. Forward Current Indicator
9. Reverse Current Indicator
10. Switch Over-Temperature Indicator
11. Magnet Over-Temperature Indicator
12. Magnet Water Flow Failure Indicator

4.1.2 - Rear Panel



1. AC Mains Input (Auxiliary Power Supply) - 115 - 220VAC, 2A
2. Fuse Holder / Voltage Selector
3. USB Port - Type B USB connection for computer control
4. Sensor Power - $\pm 12V$ power for Senis Magnetic Field Transducer
5. Sensor Input - Senis analog Magnetic Field Transducer input
6. Control Mode Switch - Selects either internal computer control or external analog control input signal.
7. Analog Input - When selected, the Power Supply Full Scale output is proportional to a 0 to 10 volt control signal applied to this terminal
8. Magnet Interlock Connection
9. Power Supply Interlock Connection
10. Ground – Power Supply and Electromagnet GROUND connection
11. Output Positive to Magnet
12. Power Supply Negative Input
13. Output Negative to Magnet
14. Power Supply Positive Input

4.2 - Initial Operational Testing – Local Mode

Once the Power Supply, Reversal Switch and Electromagnet system are connected it is time to perform initial system operational checks.

Start by switching on the Reversal Switch. The power indicator should illuminate, along with the panel meters, the power supply enable and the polarity indicator as selected by the polarity control. All interlock indicators should show green.

Temporarily disconnect the Magnet Interlock connector from the Reversal Switch. The ‘Magnet Temp’ and ‘Magnet Flow’ interlock indicators should illuminate red signifying a problem with the magnet interlocks. Re-connect the Magnet Interlock connector. The interlock indicators on the front panel should change to green.

Insure that the ‘Voltage’ and ‘Current’ controls on the DC Supply are turned down to their minimum values and switch on the DC Power Supply. Slowly turn up the voltage and current controls until about 5 amps is indicated on the DC Supply display. The panel meters on the Reversal Switch should show similar values for voltage and current.

It is important to note that for normal operation, the DC Power Supply voltage be set at Maximum. If this is not done, the DC Power Supply will be voltage limited and full output current may not be achieved.

4.3 - External Control

To use the external control option, set the ‘Control Mode’ switch on the rear panel to ‘External’. This disconnects the internal DAC and connects the DC Supply Current Input terminal to the analog input. One thing to note is that it is still possible to use the internal DAQPad for monitoring the Reversal switch even when using an external analog control signal.

Connect an analog voltage source to the Analog Input terminal. This source should be capable of delivering voltages from 0V to +10V. The power supply current output is proportional to the analog control input voltage.

4.4 - Computer Control

The 5971-160 is provided with a LabVIEW driver that allows basic control and monitoring of the Reversal Switch and DC Power Supply. To use the external control option, set the ‘Control Mode’ switch on the rear panel to ‘Internal’. This connects the internal DAC to the DC Power Supply analog control input.

Start up the computer software and ensure that everything configured correctly. Please refer to section 5 of this manual for more information.

4.4.1 - USB-6251 DAQ

The National Instruments USB-6251 DAQ together with GMW's Magnet Control software provides control and monitoring of the 5971-160 Reversal Switch. If GMW's Magnet Control software is not used, it is still possible to computer control the 5971-160 Reversal Switch by writing custom software to communicate with the USB-6251. The table below describes the channels used and their functions.

USB-6251 Connections			
Signal	Type	Direction	6251 Terminal
Current Control Output 10V output proportional to 100% current output	Analog Single Ended	Output	AO-0
Current Control Common	Ground	Ground	AO-GND
Voltage Monitor 10V / 100% of the power supply's rated output voltage	Analog Single Ended	Input	AI-0
Voltage Monitor Common	Analog	Input	AI-GND
Current Monitor 10V / 100% of the power supply's rated output current	Analog Single Ended	Input	AI-1
Current Monitor Common	Analog	Input	AI-GND
Field Monitor +	Analog	Input	AI-2
Field Monitor -	Analog	Input	AI-10
Field Monitor Common	Ground	Ground	AI-GND
- Reserved -	Digital	Input	P0.0
Switch Temp – Low = Okay	Digital	Input	P0.1
Magnet Flow – Low = Okay	Digital	Input	P0.2
Magnet Temperature – Low = Okay	Digital	Input	P0.3
P/S Enabled – High = Enabled	Digital	Input	P0.4
Polarity Status – High = Forward	Digital	Input	P0.5
Local Lockout – High = Remote	Digital	Output	P0.6
Polarity Control – High = Forward	Digital	Output	P0.7
Interlock Status Common	Ground	-	DGND
+5V Power	Power	-	+5V

Section 5

SOFTWARE

The 5971-160 Reversal Switch is provided with basic control and monitoring software. This section covers the installation and basic operation of the software.

5.1 - Software Installation

Install the software packages in the order below. This should ensure that all components are correctly installed and working.

1. Install the National Instruments software and driver package, NI-DAQmx, according to the instructions in the National Instruments software manual.
2. Connect the Reversal Switch to the computer.
3. Using the National Instruments software, Measurement and Automation Explorer, verify communication between the computer and the Reversal Switch.
4. Install the GMW Reversal Switch software.

The GMW supplied software allows basic control and monitoring. There are two options when installing the software. The first is a basic run-time version that does not allow modification of the software. The second option is a set of virtual instruments (VIs) that may be modified to suite a custom application. Note that the ability to use the VI version requires the purchase of the complete National Instruments LabVIEW software package.

5.1.1 - Installing the Run Time software version

1. Insert the GMW supplied software disc in to the CD or DVD drive.
2. Run the setup.exe located in the directory \Installer\Volume.
This will install both the runtime and source VIs and by default, the installer will place the files in the directory c:\program files\GMW 5971 Reversal Switch\. You may change this at the time of installation.
3. After the setup has completed, read the readme file for any last minute changes or notes.

5.2 - Operating the Reversal Switch using the GMW Software

Once the software is installed, it will be possible to control and monitor the Reversal Switch using the supplied software.

5.2.1 - Running the software

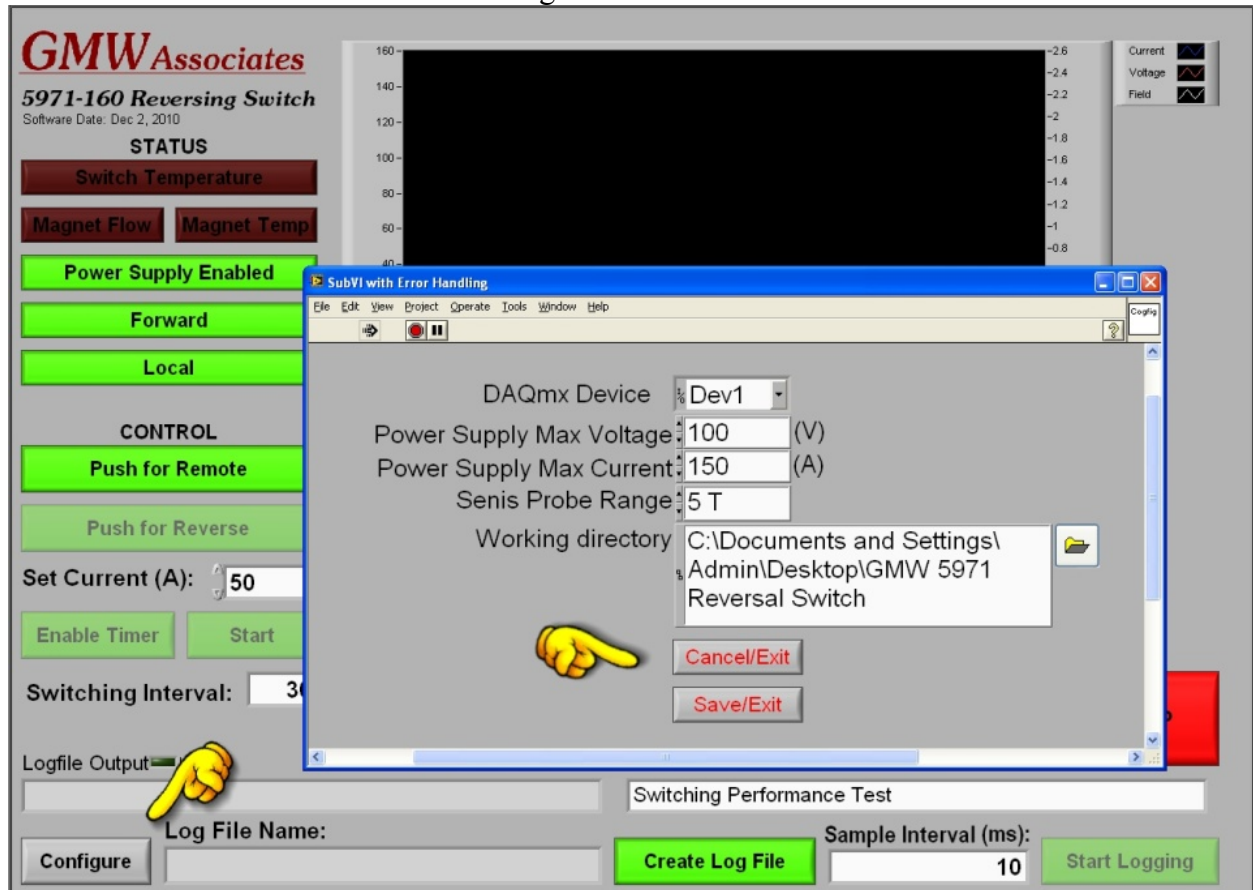
1. The runtime version is accessed via the start menu:
Start > All Programs > GMW 5971 Reversal Switch V1_0> GMW Reversal Switch 5971-160.exe
2. The source VIs are located in the directory c:\program files\GMW 5971 Reversal Switch V1_0\Source VI\. Note that LabVIEW 8.6.1 or later is required to run, view or modify the source VIs.

5.2.2 - Software Configuration

Upon the first run of the software, a simple configuration screen will be presented. Select the DC Power Supply type from the provided list. If the power supply that is being used is not listed, enter the maximum voltage and current of the DC Power Supply that you have. Then select the address of the USB-6251 DAQ from the list. You may also enter the default directory to be used for storing data generated from the data logger.

Save and exit the configuration screen.

Configuration Screen



5.2.3 - Basic Operation

Once configured, the normal operation screen will be presented. This screen provides control of current and polarity and monitoring of the DC Power Supply's output voltage and current. It also provides status read back of the Reversal Switch and Electromagnet interlock status.

It is important to note that when operating remotely, the DC Power Supply front panel controls be set as follows: Voltage to Maximum, Current to zero. If this is not done, the DC Power Supply will be voltage limited and full output current may not be achieved.

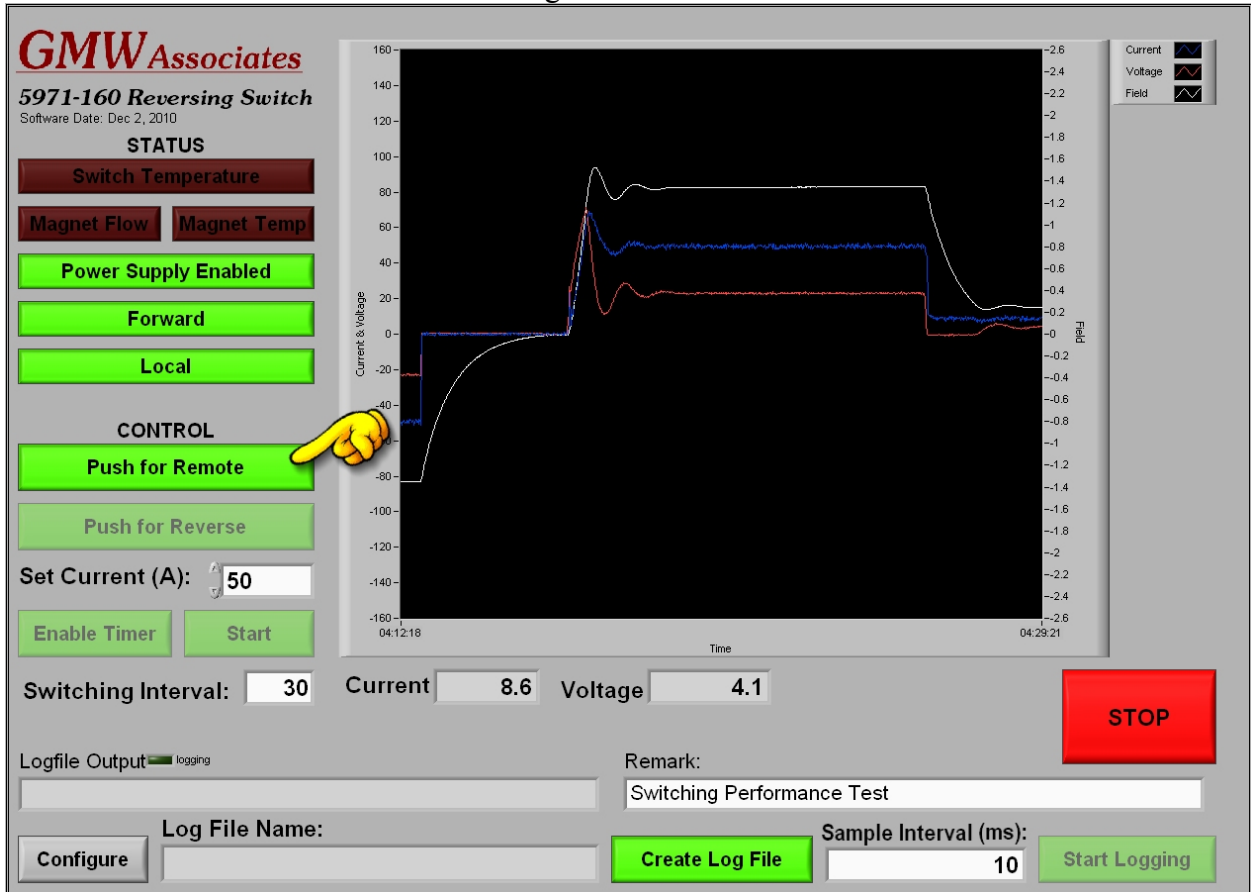
5.2.4 - Local / Remote

The Reversal Switch software defaults to local operation. In order to control the Reversal Switch it must first be placed into the 'Remote' mode. This is done by clicking on the Local / Remote' Control. This control will change its state depending on what mode it is in. The two states are:

'Local' - The control is green and displays the legend 'Push for Remote'

'Remote' - The control is yellow and displays the legend 'Push for Local'

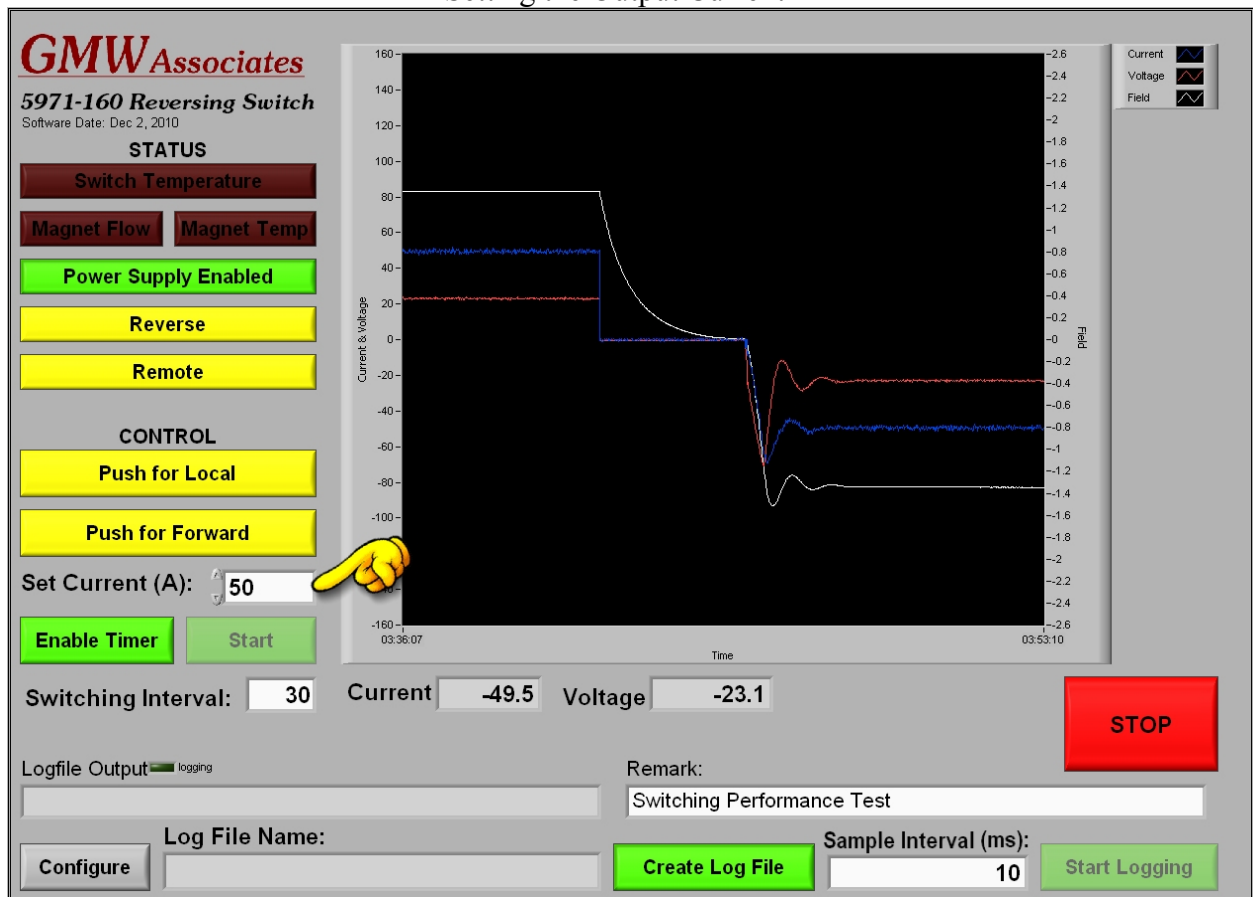
Selecting Local or Remote



5.2.5 - Setting the output current

The output current is simply set by entering the desired output current in the current control box.

Setting the Output Current

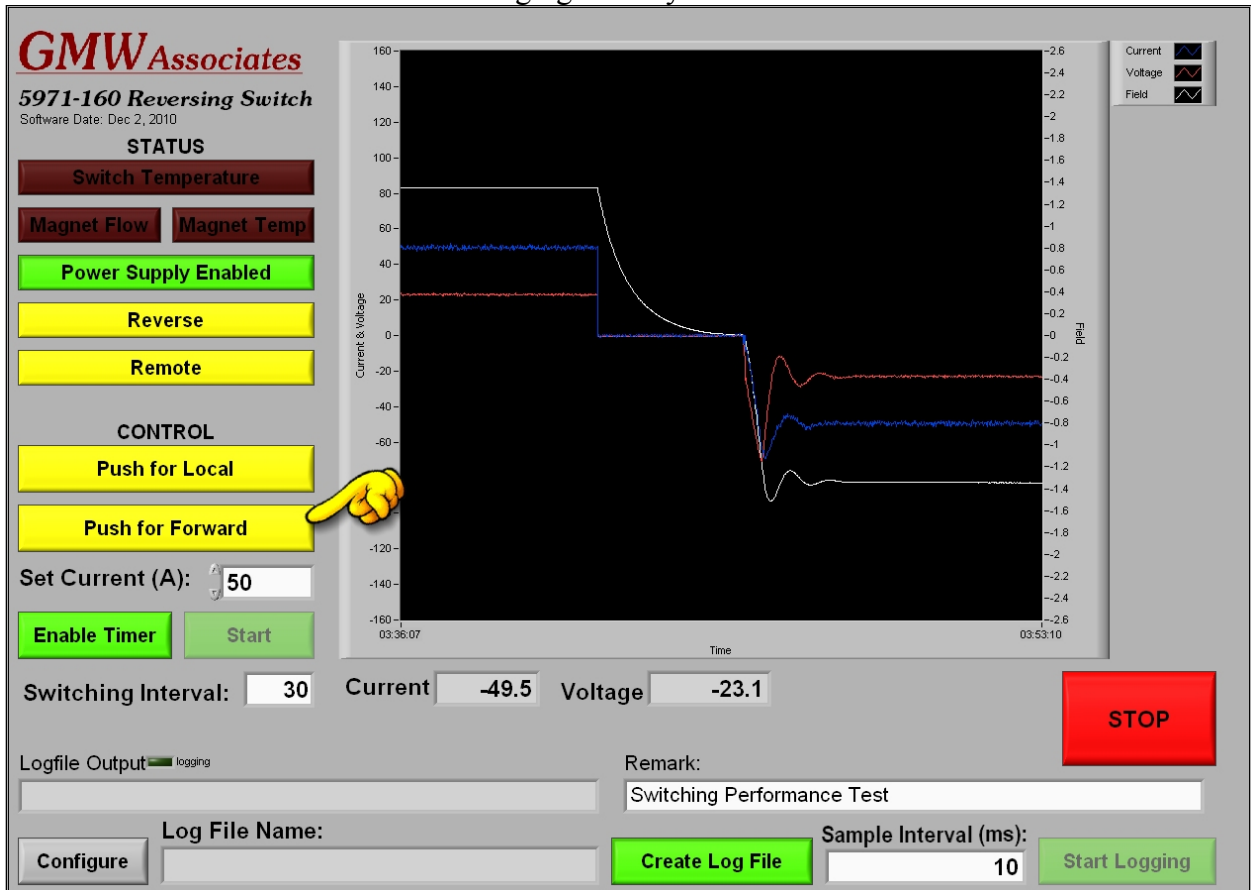


5.2.6 - Selecting the Reversal Switch polarity

To change the Reversal Switch polarity, simply click on the polarity control toggle. The Reversal Switch will then inhibit the DC Power Supply's output, wait for the voltage to drop to a safe level, change polarity and then re-enable the DC Power Supply's output.

The switching time will depend on the configuration of the load. Switching times may approach 20 seconds.

Changing Polarity

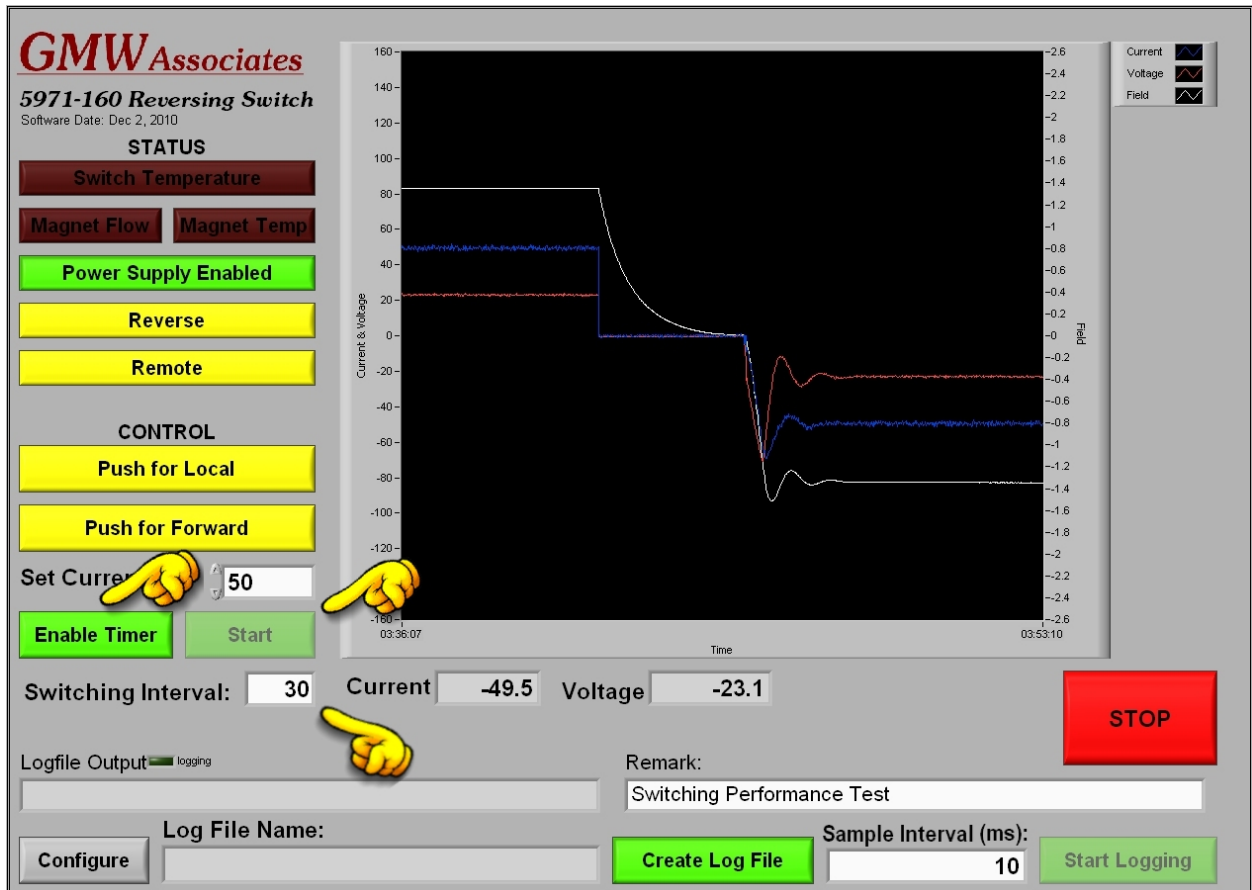


5.2.7 - Timed Switching

The software has the ability to automatically switch at a rate chosen by the operator. To use the timed switching function follow the procedure below.

1. Push the 'Enable Timer' button.
2. Enter the desired time switching interval in seconds. Note that 30 seconds is the minimum interval.

Timer Enable and Interval



3. Press the 'Start' button.

Note that while timed switching is enabled, the regular forward / reverse control is disabled..

5.2.8 - Data Logging

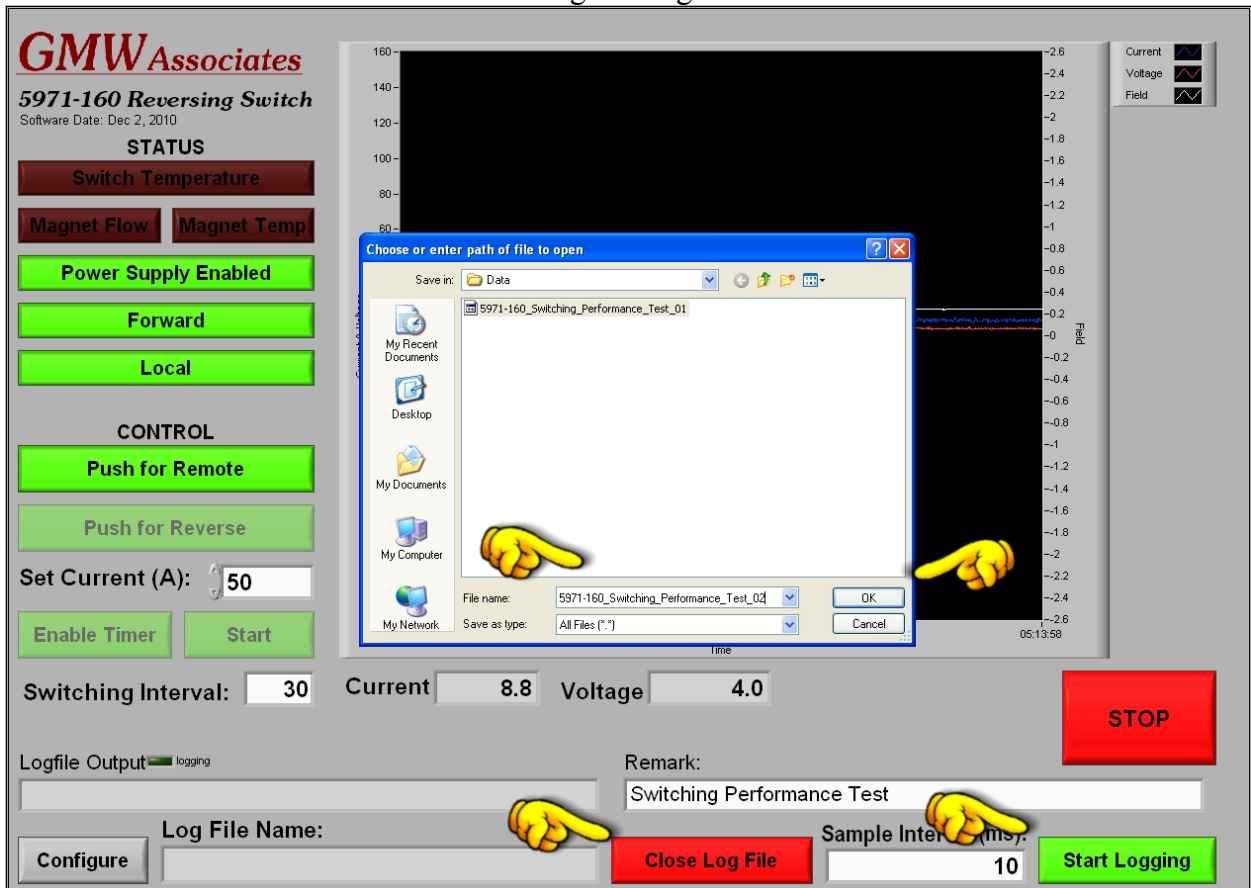
There are a few things to set up in order to use the data logger:

1. Push the 'Create Log File' button. This will open a dialog box that will prompt for the file name of the log file. If the file exists, it will prompt for confirmation to over write the existing file.
2. Enter a log file sample interval (in mili-seconds). Set to 0 to log every sample.

Note at this time, data is NOT being logged.

3. To start the logging, click on the green 'Start Logging' button. The button will then change to a red 'Pause Logging' Button.
4. To stop or pause the logging, click on the red 'Pause Logging' button. The button will change back to the green 'Start Logging' button.
5. To close the log file, click on the 'Close Log File' button.

Creating the Log File

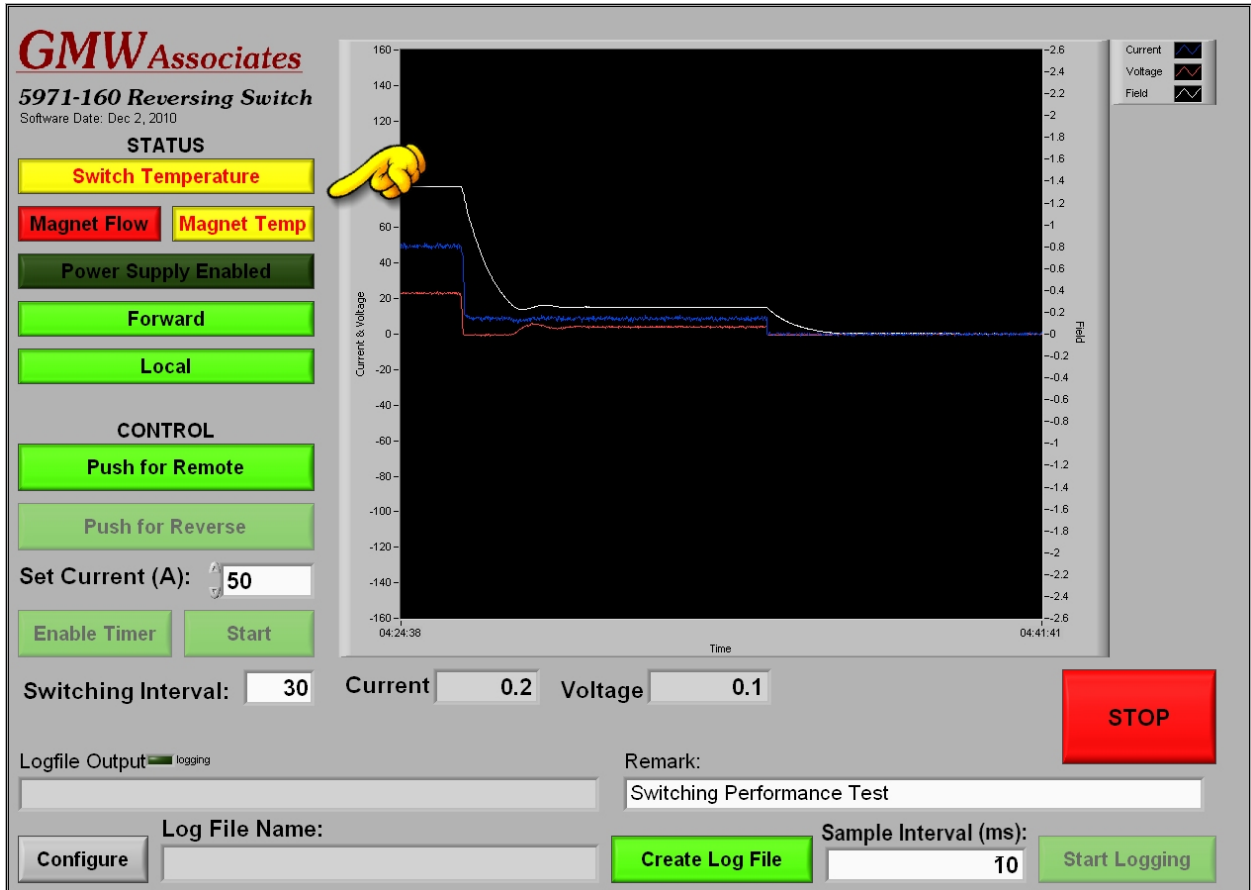


5.2.9 - Status Read Back

This software will read back the Reversal Switch status regardless of its Local / Remote status. The status read back consists of three interlock indicators and the general status indicators.

If any one of the interlock conditions exists, the corresponding indicator will flash on the screen and the DC Power Supply's output will be disabled.

Interlock and Status Indicators



Section 6

MAINTENANCE

The 5971-160 Current Reversal Switch should operate for many years without any trouble provided that the following basic maintenance points are observed. Always remember that the AC power should be disconnected before performing any maintenance procedure. The 5971-160 may generate lethal voltages and must not be operated with damaged components, protective covers or cable insulation. For more information, please refer to Section 2, Warnings

1. Electrical Connections: Ensure that all electrical connections are clean and tight. Ensure that the insulation of all electrical cables is undamaged and repair or replace if necessary. All electrical termination covers must be in place and firmly secured.

A corroded and / or loose high current connection will cause a voltage drop across the connection. A drop of 0.1V at 160A results in 16W being dissipated at the connection. The connection will increase in temperature which will result in oxidation or the connection, a higher resistance and a further increase in power dissipation. If this situation is left uncorrected the cable and Reversal Switch insulation will melt and possibly the copper connections will melt as well. Not only will the Reversal Switch and nearby equipment be damaged, but there is the possibility for fire.

2. Warning Labels: Ensure that all protective covers on the system and the magnet are in place. There are warning labels on all removable covers.

3. Cooling: Check that the fans are clean and free of blockage. Ensure that the fans are operating at full efficiency.

4. Cleaning: To clean wipe the case with a soft cloth with a mild detergent or plain water. Do not use any solvents as they may damage the finish.

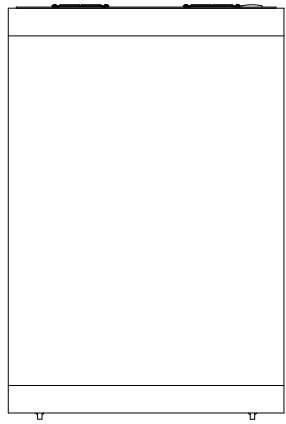
Section 7

DRAWINGS

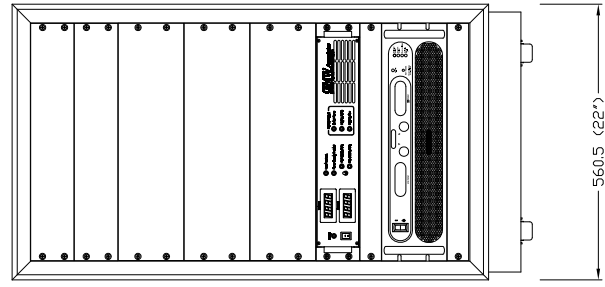
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REVISIONS			
REV	DESCRIPTION	DRAFT	DATE
A	RELEASE		9 Nov, 2010
			M. Duffy

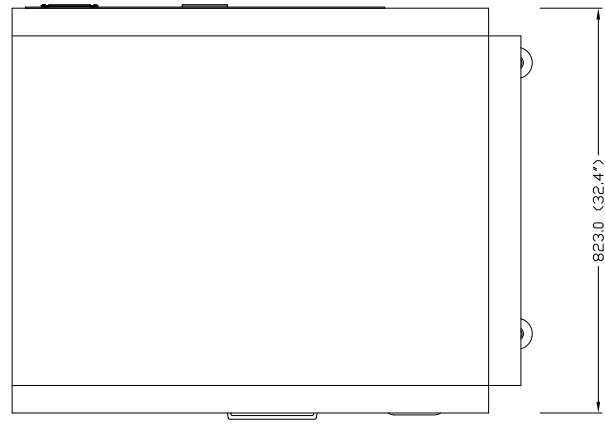
SIDE VIEW



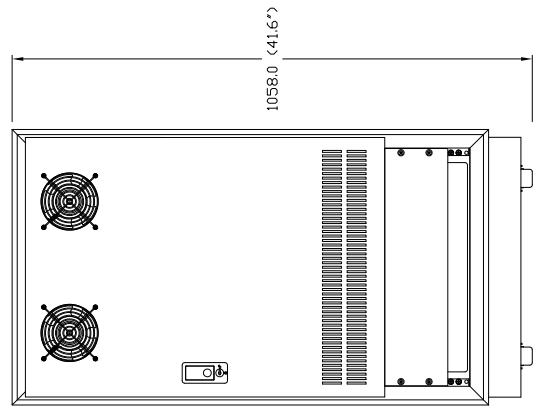
FRONT VIEW



SIDE VIEW



REAR VIEW



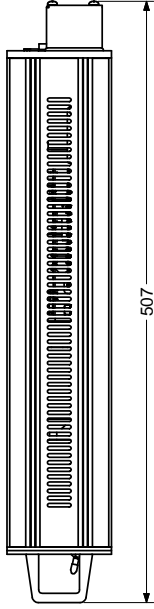
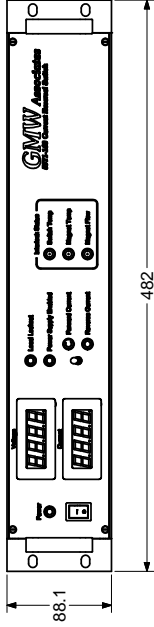
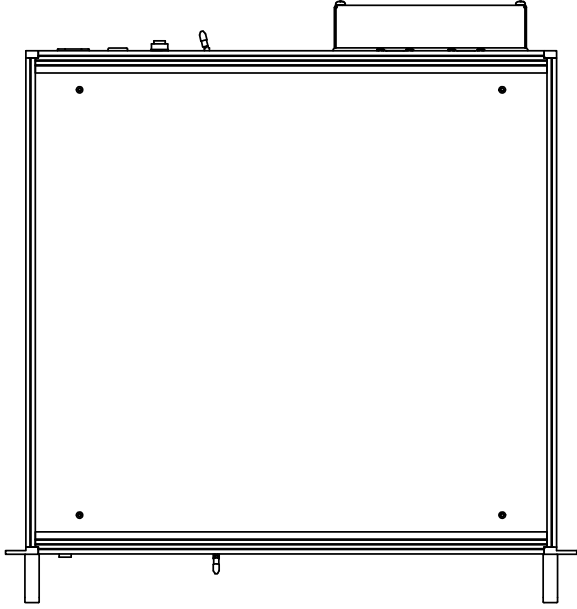
- 2U FILLER PANEL
- 2U FILLER PANEL
- 3U FILLER PANEL
- 3U FILLER PANEL
- 3U FILLER PANEL
- 5971-160 REVERSING SWITCH
- 1U FILLER PANEL
- SORENSEN SGA SERIES DC POWER SUPPLY
- 1U FILLER PANEL

RACK MODEL: OPTIMA RC-351930
APPROX. WEIGHT: 135kg (300lbs) System with SGA 160/31 DC Power Supply
141kg (314lbs) System with SGA 160/63 DC Power Supply

ITEM	QTY	PART NUMBER	DESCRIPTION	NOTE
PARTS LIST				
DO NOT SCALE FROM DRAWING				
DRAWN	DATE	DATE	G.M.W.	
CHECKED	DATE	DATE	955 Industrial Rd, San Carlos, CA 94070	
ENGINEERING	DATE	DATE	Tel: (650)802-8292. Fax: (650)802-8298.	
	DATE	DATE	TITLE	
	DATE	DATE	5971-160 MOSFET Reversing	
	DATE	DATE	Switch - Rack Assembly	
	DATE	DATE	SIZE	
	DATE	DATE	A1 11907-0154-0	
	DATE	DATE	REV	
	DATE	DATE	A	
	DATE	DATE	SCALE 1:5	
	DATE	DATE	SHEET 1 OF 1	

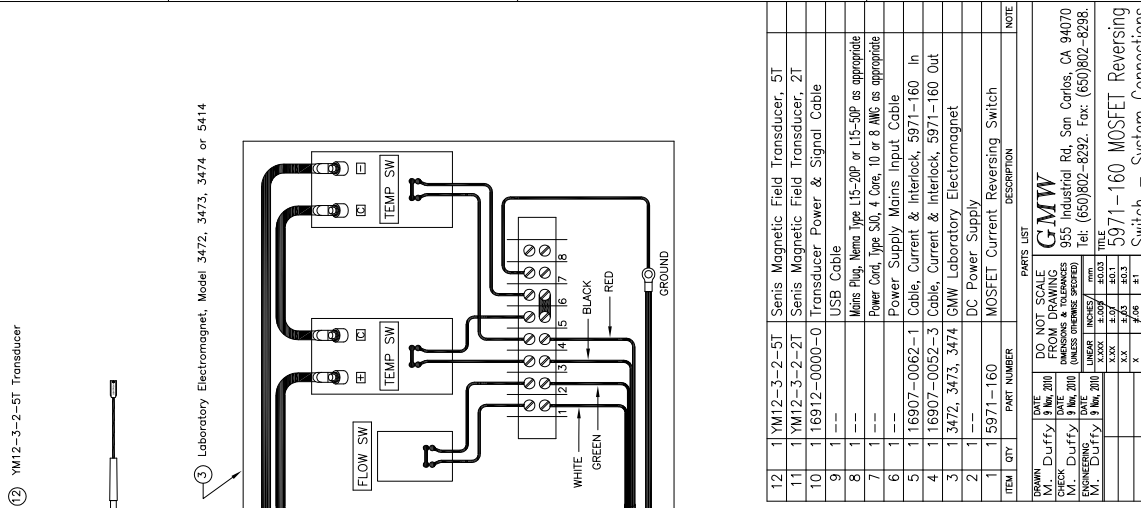
PROPRIETARY
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INFORMATION PROPRIETARY TO GWM INC. IT MUST
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FORM OR BY ANY MEANS, ELECTRONIC OR
MECHANICAL, INCLUDING PHOTOCOPYING,
RECORDING, OR BY ANY INFORMATION
SYSTEMS WITHOUT PERMISSION IN WRITING
EXCEPT AS AUTHORIZED IN WRITING BY GWM INC.

ZONE	REV	DESCRIPTION	DATE	APPROVED
	A	Release	10/20/2009	Michael E. Duffy
	B	Update Front Panel	02/23/2010	Michael E. Duffy
	C	Update Rear Panel Text	11/22/2010	Michael E. Duffy



Weight: 15.75kg (35Lbs)
Power Input: 115-220VAC, 50/60 Hz, 2A
Max Switched Power: 200V, 160A

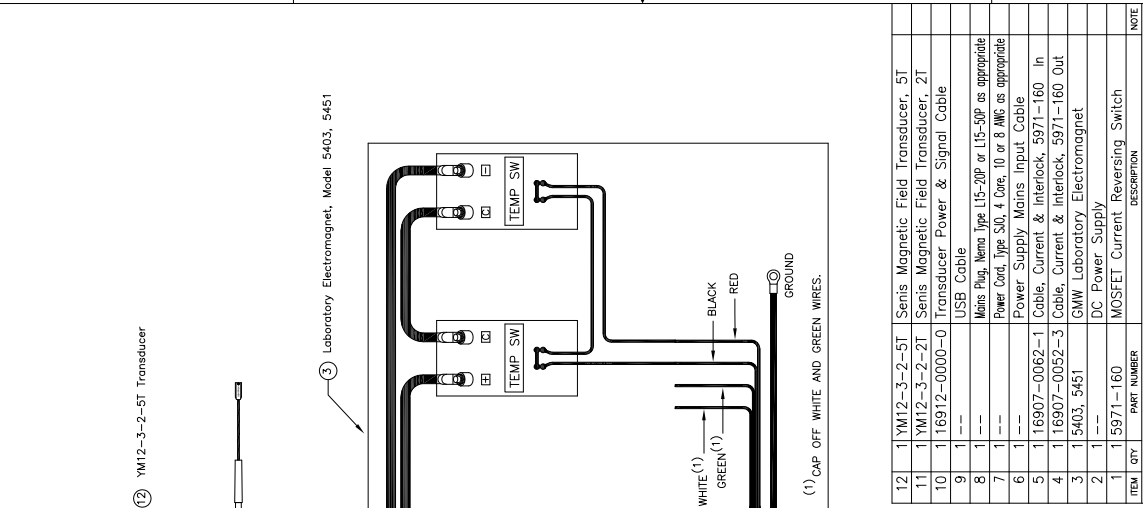
DESIGNED BY M. Duffy	DATE 20 Oct, 2009	DO NOT SCALE FROM DRAWING	GMW Associates 955 Industrial Road, San Carlos, CA 94070 Tel: (650) 802-8292, Fax: (650) 802-8298
CHECKED BY M. Duffy	DATE 20 Oct, 2009	LINEAR X.XXX ±.01 X.XX ±.1 X.X ±.3 X.XX ±.01 X.XX ±.1 X.XX ±.3	5971-160 MOSFET Reversing Switch - General Assembly
APPROVED BY M. Duffy	DATE 20 Oct, 2009	THIRD ANGLE PROJECTION	SCALE: NTS
DRAWING NO. A2 11907-0153-0		SIZE C	WT.: kg
SHEET: 1		OF: 1	



ITEM NO.	DATE	REVISION	NOTE
12	1	YM12-3-2-5T	Senis Magnetic Field Transducer, 5T
11	1	YM12-3-2-2T	Senis Magnetic Field Transducer, 2T
10	1	16912-0000-0	Transducer Power & Signal Cable
9	1	---	USB Cable
8	1	---	Mains Plug, Nema Type 15-20P or 15-50P as appropriate
7	1	---	Power Cord, Type S0, 4 Ore, 10 or 8 AWG as appropriate
6	1	---	Power Supply Mains Input Cable
5	1	16907-0062-1	Cable, Current & Interlock, 5971-160 In
4	1	16907-0052-3	Cable, Current & Interlock, 5971-160 Out
3	1	3472, 3473, 3474	GNW Laboratory Electromagnet
2	1	---	DC Power Supply
1	1	5971-160	MOSFET Current Reversing Switch

[illegible]

MAINS INPUT:
DLM40-75E DC POWER SUPPLY: 180-264V, 16A, 50/60Hz, 3 ϕ
SCA 60/83 DC POWER SUPPLY: 187-242V, 21A, 50/60Hz, 3 ϕ
SCA 100/150 DC POWER SUPPLY: 187-242V, 62A, 50/60Hz, 3 ϕ
SCA 160/156 DC POWER SUPPLY: 187-242V, 103A, 50/60Hz, 3 ϕ
SCA 200/75 DC POWER SUPPLY: 187-242V, 103A, 50/60Hz, 3 ϕ



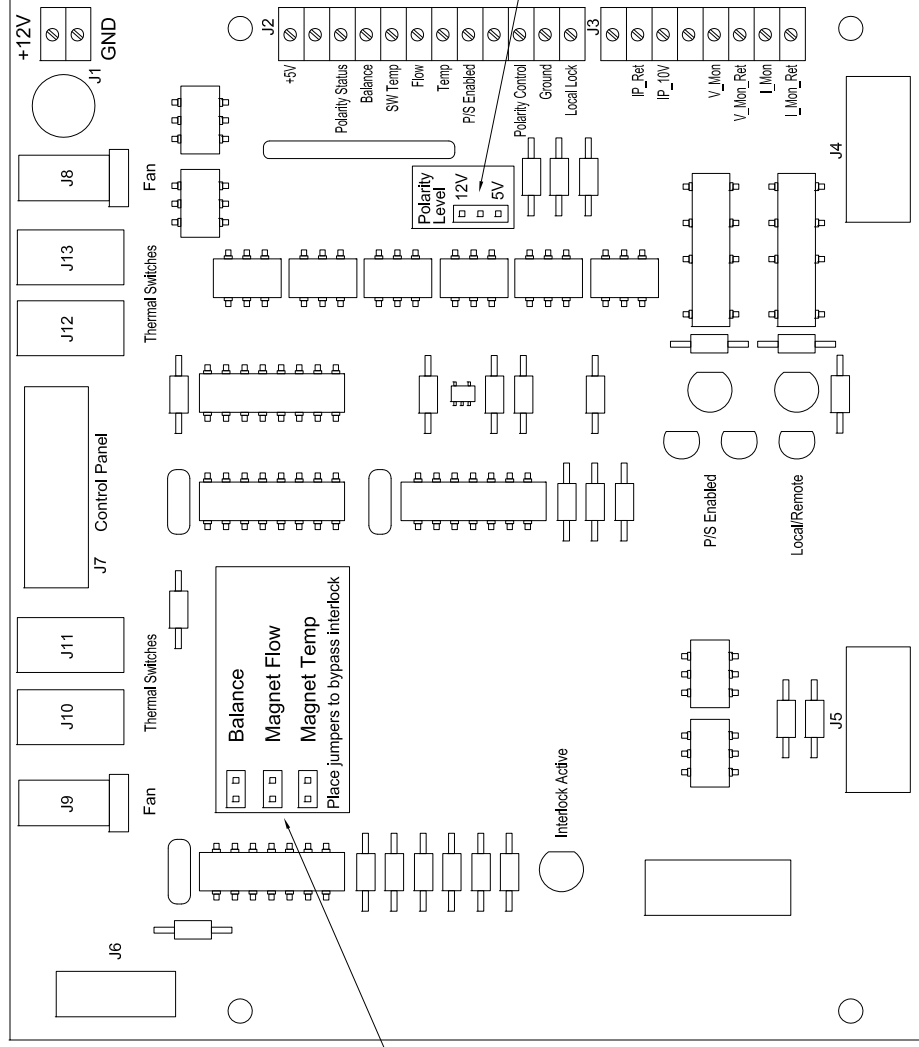
DRAWN		DATE	DO NOT SCALE		PARTS LIST	
1	Duffy	9 Nov 2010	1	1		
CHECK	DATE					
2	Duffy	9 Nov 2010				
3	Duffy	9 Nov 2010				
NOTED: Duffey						
<p>955 Industrial Rd. San Carlos, CA 94070 (650)802-8322 Fax: (650)802-8398</p>						
<p>3971-160 MOSFET Reversing Switch - System Connections</p>						
<p>SIZE DRAWING NO. REV</p>						
<p>A1 1907-0009-1 A</p>						
<p>WT KG</p>						
<p>SHEET 1 OF 1</p>						
<p>SOFTWARE AUTOCAD 2000</p>						

MAINS INPUT:
DLM40-75E DC POWER SUPPLY: 180-264V, 16A, 50/60Hz, 3 ϕ
SCA 60/83 DC POWER SUPPLY: 187-242V, 21A, 50/60Hz, 3 ϕ
SCA 100/150 DC POWER SUPPLY: 187-242V, 62A, 50/60Hz, 3 ϕ
SCA 150/200 DC POWER SUPPLY: 187-242V, 103A, 50/60Hz, 3 ϕ
SCA 200/75 DC POWER SUPPLY: 187-242V, 103A, 50/60Hz, 3 ϕ

7 Mains Cable, Type SJO, See below for sizing.
5m long. ** USER SUPPLIED **

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IS PROHIBITED BY GMW INC.

REVISIONS			
REV	DESCRIPTION	DRAWN	DATE
A	RELEASE	M. Duffy	9 Nov 2010
APPROVED			
M. Duffy			



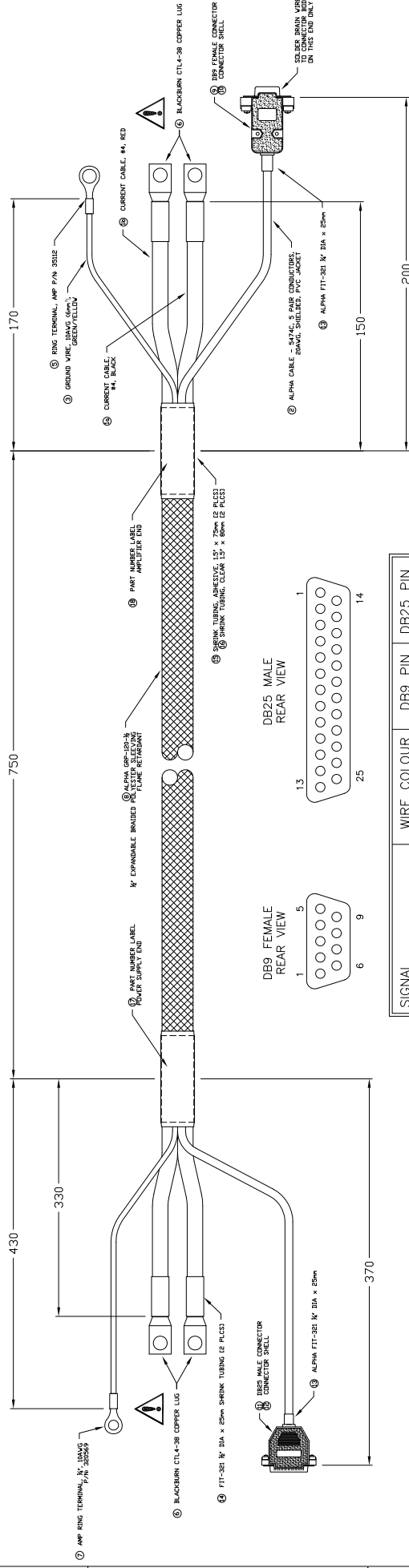
PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
DRAWN: Duffy, M. DATE: 9 Nov 2010			
CHECKED: Duffy, M. DATE: 9 Nov 2010			
ENGINEERING: Duffy, M. DATE: 9 Nov 2010			
DO NOT SCALE FROM DRAWING UNLESS OTHERWISE SPECIFIED			
LINEAR DIMENSIONS SPECIFIED IN INCHES			
DECIMALS: 0.003 0.005 0.010 0.015 0.020 0.030 0.040 0.050 0.060 0.070 0.080 0.090 0.100 0.125 0.150 0.175 0.200 0.250 0.300 0.375 0.500 0.625 0.750 0.875 1.000 1.250 1.500 1.750 2.000 2.500 3.000 3.500 4.000 4.500 5.000 5.500 6.000 6.500 7.000 7.500 8.000 8.500 9.000 9.500 10.000			
ANGLES: 15 30 45 60 75 90 105 120 135 150 165 180			
THIRD ANGLE PROJECTION			
NEXT ASSY: SYSTEM SOFTWARE: AUTOCAD 2000			
SCALE: 1X907-0000-0			
SHEET 1 OF 1			

GMW
955 Industrial Rd, San Carlos, CA 94070
Tel: (650)802-8292. Fax: (650)802-8298.
5971-160 MOSFET Reversal
Switch - Jumper Configuration
Drawing No. A11X907-0000-0
REV: A

REVISIONS				
REV	DESCRIPTION	DRAFT	DATE	APPROVED
A	RELEASE		9 Nov, 2010	M. Duffy

"A" END
CONNECT TO SGA DC POWER SUPPLY

"B" END
CONNECT TO 5971-160
REVERSAL SWITCH



SIGNAL	WIRE COLOUR	DB9 PIN	DB25 PIN
PS ON/OFF COMMON	BLACK	9	24
PS ON/OFF CONTACT	RED	8	5
CURRENT MONITOR	WHITE	3	7
CURRENT MONITOR RTN	BLACK	4	6
VOLTAGE MONITOR	BLUE	6	19
VOLTAGE MONITOR RTN	BLACK	7	6
CURRENT PROG. 10V	YELLOW	1	16
CURRENT PROG. RTN	BLACK	2	23
COMMON	GREEN	5	24

CUT LENGTHS:

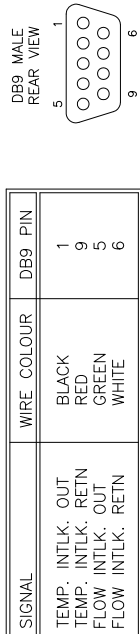
CURRENT CABLE	— 1230mm
GROUND	— 1350mm
INTERLOCK	— 1320mm

⚠ WARNING: THE RED (POSITIVE) TERMINATION OF THE CABLE MUST BE CONNECTED TO THE POSITIVE TERMINALS OF THE DC POWER SUPPLY AND THE 5971-160 REVERSING SWITCH. INCORRECT CONNECTION WILL DAMAGE THE REVERSING SWITCH, VOIDING THE WARRANTY.

NOTE:

1. REFER TO DRAWING 169XX-0000-0 FOR BASIC CABLE ASSEMBLY
2. MAXIMUM CONTINUOUS CURRENT: 70 Amps
3. TOTAL CABLE RESISTANCE: 0.0025 Ohms
4. NOMINAL VOLTAGE DROP @ MAXIMUM CURRENT: 0.18 Volts

[illegible][illegible]



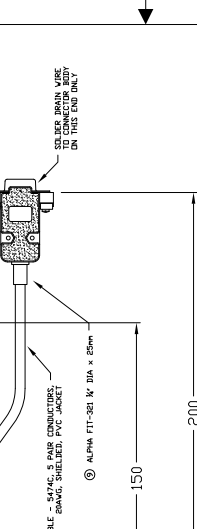
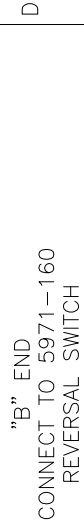
ITEM	QTY	PART NUMBER	DESCRIPTION	NOTE
17	1	10907-0059-1	LABEL, MAGNET END	
16	1	10907-0059-0	LABEL, MAGNET END	
15	2	FIT-2271-1-CLEAR	SHRINK TUBING, CLEAR, 1" X 80mm	
14	2	FIT-321-1	SHRINK TUBING, ADHESIVE WALL, 1" X 75mm	
13	1	FIT-321-1/2	SHRINK TUBING, ADHESIVE WALL, 1/2" X 25mm	
12	1	FIT-321-1/4	SHRINK TUBING, ADHESIVE WALL, 1/4" X 25mm	
11	2	CBBE301005	S-SUB 9 PIN CONNECTOR HOOD	
10	1	5-747904-2	D-SUB 9 PIN CONNECTOR, MALE, SLIDER CLIP	
9	A/R	GRP-120-2	EXPANDABLE POLYESTER SLEEVING, FOLDE RETARDANT	
8	1	3205659	FORK TERMINAL, #6, 12 - 10AWG	
7	4	326861	RING TERMINAL, #6, 22 - 16AWG	
6	2	CT1414	COPPER COMPRESSION LUG, #4 CABLE, 3/8" STUD	
5	1	CT1414	RING TERMINAL, PIDG, 10AWG, 3/8" STUD	
4	2	CT14-38	COPPER COMPRESSION LUG, #4 CABLE, 3/8" STUD	
3	A/R	86026030	COPPER WIRE, 6mm ² , GREEN/YELLOW	
2	A/R	B9444	CABLE, 4 CONDUCTORS, 20AWG, PVC JACKET	
1b	A/R	A20048-02	CABLE, COBRA X-FLEX, #4, RED INSULATION	
1a	A/R	A20048-07	CABLE, COBRA X-FLEX, #4, BLACK INSULATION	

CUT LENGTHS:

CURRENT CABLE	— 5580mm
GROUND	— 5360mm
INTERLOCK	— 5500mm

1. REFER TO DRAWING 169XX-0000-0 FOR BASIC CABLE ASSEMBLY
2. MAXIMUM CONTINUOUS CURRENT: 70 Amps
3. TOTAL CABLE RESISTANCE: 0.0115 Ohms
4. NOMINAL VOLTAGE DROP @ MAXIMUM CURRENT: 0.81 Volts

DRAWN BY			DATE	DO NOT SCALE		PARTS LIST	
M. Duffy			9 Nov. 2016				
CHECK BY			DATE				
M. Duffy			9 Nov. 2016				
APPROVED BY			DATE				
M. Duffy			9 Nov. 2016				
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES (UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS)				GMW 955 Industrial Rd. San Carlos, CA 94070 (650)802-8322 Fax: (650)802-8398			
LINEAR		INCHES		mm			
FRACTIONS							
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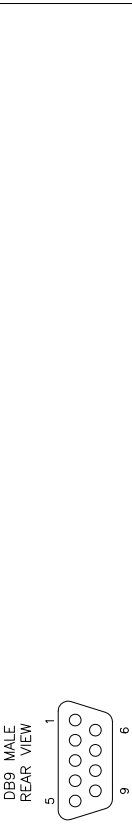
18	1	C88E321005	S-SUB 25 PIN CONNECTOR HOOD
17	1	5-747912-2	O-SUB 25 PIN CONNECTOR, MALE, SOLDER CUP
16	1	C88E301005	S-SUB 9 PIN CONNECTOR HOOD

11	4	FIT-321-1	SHRINK TUBING, ADHESIVE WALL, 1" X 70mm
10	2	FIT-321-1/2	SHRINK TUBING, ADHESIVE WALL, 1/2" X 25mm
9	2	FIT-321-1/4	SHRINK TUBING, ADHESIVE WALL, 1/4" X 25mm
8	2	FIT-221-1.5-CLEAR	SHRINK TUBING, CLEAR, 1.5" X 100mm
7	2	FIT-321-1.5	SHRINK TUBING, ADHESIVE WALL, 1.5" X 90mm
6	A/R	EXPANDABLE POLYESTER SLEEVING, 1.5" REMnant	
5	2	FIT-11-1/4	COPPER COMPRESSION LUG, 1/4" CABLE, % STUD
4	4	CIL4-38	COPPER COMPRESSION LUG, 2/0 CABLE, % STUD
3	4	LCB 2/0-38	COPPER COMPRESSION LUG, 2/0 CABLE, % STUD

DRAWN M. Duffy	DATE 9 Dec, 2010	DO NOT SCALE FROM DRAWING	GMW
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- [illegible]

NEXT ASSY	SYSTEM	FINISH	80	✓	100%	THIRD ANGLE PROJECTION	SCALE	WT kg	SHEET 1 OF 1	DRAWING NO.	REV
SOFTWARE AUTOCAD	2000									A1 16907-0062-2	A



SIGNAL	WIRE COLOUR	DB9 PIN
TEMP. INTLK. OUT	BLACK	1
TEMP. INTLK. RETN	RED	9
FLOW INTLK. OUT	GREEN	5
FLOW INTLK. RETN	WHITE	6

CUT LENGTHS:

CURRENT CABLE	— 5580mm
GROUND	— 5360mm
INTERLOCK	— 5500mm

1. REFER TO DRAWING 169XX-0000-0 FOR BASIC CABLE ASSEMBLY
2. MAXIMUM CONTINUOUS CURRENT: 160 Amps
3. TOTAL CABLE RESISTANCE: 0.0036 Ohms
4. NOMINAL VOLTAGE DROP @ MAXIMUM CURRENT: 0.58 Volts

ITEM	QTY	PART NUMBER	DESCRIPTION	NOTE
17	4	326861	AMP PIDG FRT TERMINAL, #6, 22 - 16AWG	
16	1	C88E3X01005	S-SUB 9 PIN CONNECTOR HOD	
15	1	5-747905-2	D-SUB 9 PIN CONNECTOR, MALE, SOLDER CUP	
14	1	10907-0059-1	LABEL, MAGNET END	
13	1	10907-0059-0	LABEL, REVERSAL SWITCH END	
12	2	FIT-221-1-RED	SHRINK TUBING, RED, 1" x 60mm	
11	4	FIT-321-1	SHRINK TUBING, RED, 1" x 70mm	
10	2	FIT-321-1-1/2	SHRINK TUBING, ADHESIVE WALL, 1/2" x 25mm	
9	2	FIT-321-1-1/4	SHRINK TUBING, ADHESIVE WALL, 1/4" x 25mm	
8	2	FIT-221-1-5-CLEAR	SHRINK TUBING, CLEAR, 1.5" x 100mm	
7	2	FIT-321-1-5	SHRINK TUBING, ADHESIVE WALL, 1.5" x 90mm	
6	A/R	XPANABLE POLYESTER SLEEVING, FLAME RETARDANT		
5	2	CL14-38	COPPER COMPRESSION LUG, 4/8 CABLE, 3/8" STUD	
4	4	LCB 270-38	COPPER COMPRESSION LUG, 2/0 CABLE, 3/8" STUD	
3	A/R	54756	CABLE, 5 PAIR, SHIELDED, 20AWG, PVC JACKET	
2	A/R	A2004B	CABLE, W/4, COBRA X-FLEX, BLACK	
1	A/R	A2002B-07	CABLE, COBRA X-FLEX, 2/0, BLACK INSULATION	

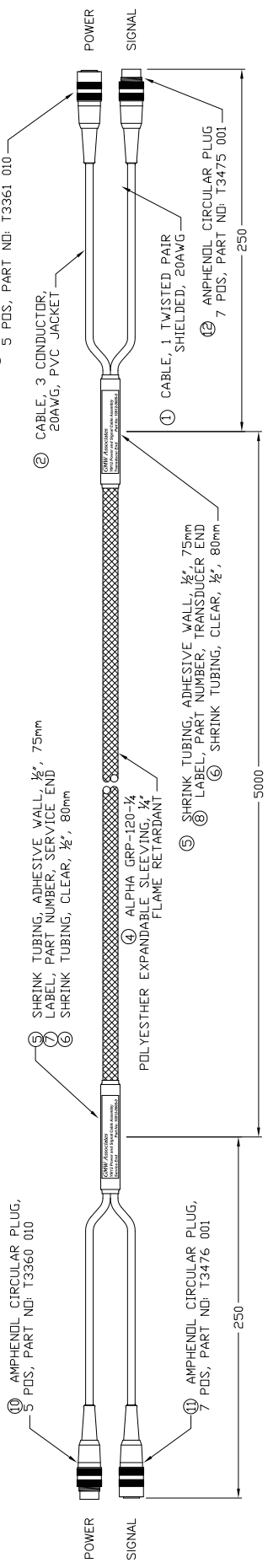
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M. Duffy		9 Dec 2010				
CHECKED BY		DATE				
M. Duffy		9 Dec 2010				
NOTED BY		DATE				
M. Duffy		9 Dec 2010				
UNIT			INCHES		mm	
LINEAR			INCHES		mm	
AREA			SQ IN		SQ CM	
VOLUME			CU IN		CU CM	
X X			X X		X X	
Y Y			Y Y		Y Y	
Z Z			Z Z		Z Z	
FINISH			FINISH		FINISH	
TYP			TYP		TYP	
NEXT ASSY			SYSTEM		REV	
SOFTWARE			AUTOCAD		SHEET 1 OF 1	
AUTOCAD			2000		A1 16907-0053-3 A	

PROPRIETARY
THIS DRAWING CONTAINS CONFIDENTIAL INFORMATION
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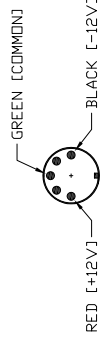
REV	DESCRIPTION	DRAFT	DATE	APPROVED
A	RELEASE		5 Aug 08	M. Duffy
B	CORRECT POLARITY OF SIGNAL CONNECTOR		18 Dec 08	M. Duffy
C	CHANGE SIGNAL CABLE SPECIFICATION		20 Feb 09	M. Duffy

SERVICE END

TRANSDUCER END



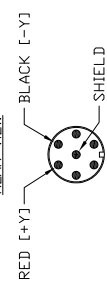
POWER CONNECTOR
REAR VIEW



SERVICE END LABEL 2:1

GMW Associates
YM12 Power and Signal Cable Assembly
Service End
Part No: 16912-0000-0

SIGNAL CONNECTOR
REAR VIEW



TRANSDUCER END LABEL 2:1

GMW Associates
YM12 Power and Signal Cable Assembly
Transducer End
Part No: 16912-0000-0

ITEM	QTY	PART NUMBER	DESCRIPTION	NOTE
12	1	T3475 001	AMPHENOL CIRCULAR CONNECTOR, 7 POS, MALE	
11	1	T3476 001	AMPHENOL CIRCULAR CONNECTOR, 7 POS, FEMALE	
10	1	T3360 010	AMPHENOL CIRCULAR CONNECTOR, 5 POS, MALE	
9	1	T3361 010	AMPHENOL CIRCULAR CONNECTOR, 5 POS, FEMALE	
8	1		LABEL, PART NUMBER, TRANSDUCER END	
7	1		LABEL, PART NUMBER, SERVICE END	
6	2	FIT-221-1/2-CLEAR	SHRINK TUBING, CLEAR, 1/2" x 80mm	
5	2	FIT-321-1/2	SHRINK TUBING, ADHESIVE WALL, 1/2" x 75mm	
4	A/R	GRP-120-1/4	POLYESTER EXPANDABLE SLEEVING, 1/4"	
3	A/R	B9444	ELECTRICAL TAPE, 1/2" x 50mm, BLACK	
2	A/R		CABLE, 4 CONDUCTOR, 20AWG	
1	A/R	318-059-2002-B	CABLE, 1 TWISTED PAIR, SHIELDED, 20AWG	

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CHKD			DATE	5 Aug 08		
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Section 8
PHOTOGRAPHS



5971-160 Front View



5971-160 Rear View

Section 9

5971-160 with GMW ELECTROMAGNETS

9.1 Table - GMW Electromagnets and appropriate DC Power Supplies for use with the 5971-160 Current Reversal Switch

GMW Electromagnet	Peak DC Power	Ametek - Sorenson Power Supply
5403, 5403EG, 5403FC, 5403AC	70A, 33V, 2.3kW	DLM40-75E, 40V, 75A, 3kW
5404	70A, 160V, 11.2kW	SGA 200/75, 200V, 75A, 15kW
3472-50, 3472-70	70A, 50V, 3.5kW	SGA 60/83, 60V, 83A, 5kW
3473-50, 3473-70	70A, 59V, 4.1kW	SGA 60/83, 60V, 83A, 5kW
3474, 5501	140A, 76V, 10.6kW	SGA100/150, 100V, 150A, 15kW
5414	140A, 116V, 16.2kW	SGA160/150, 160V, 150A, 25kW
5451	70A, 25V, 1.75kW	DLM40-75E, 40V, 75A, 3kW

9.2 Performance Data

GMW Associates

5971-160 Reversing Switch Performance Plot

Contract No: 9625

Page: 1 of 1

Date: 2 Dec, 2010

Customer: Army Research Lab

Engr: M. Duffy

5971-160 Serial No: 02

Power Supply: P83C-100150

Serial No: 0250A00730

Magnet Model: 3474

Serial No: 105

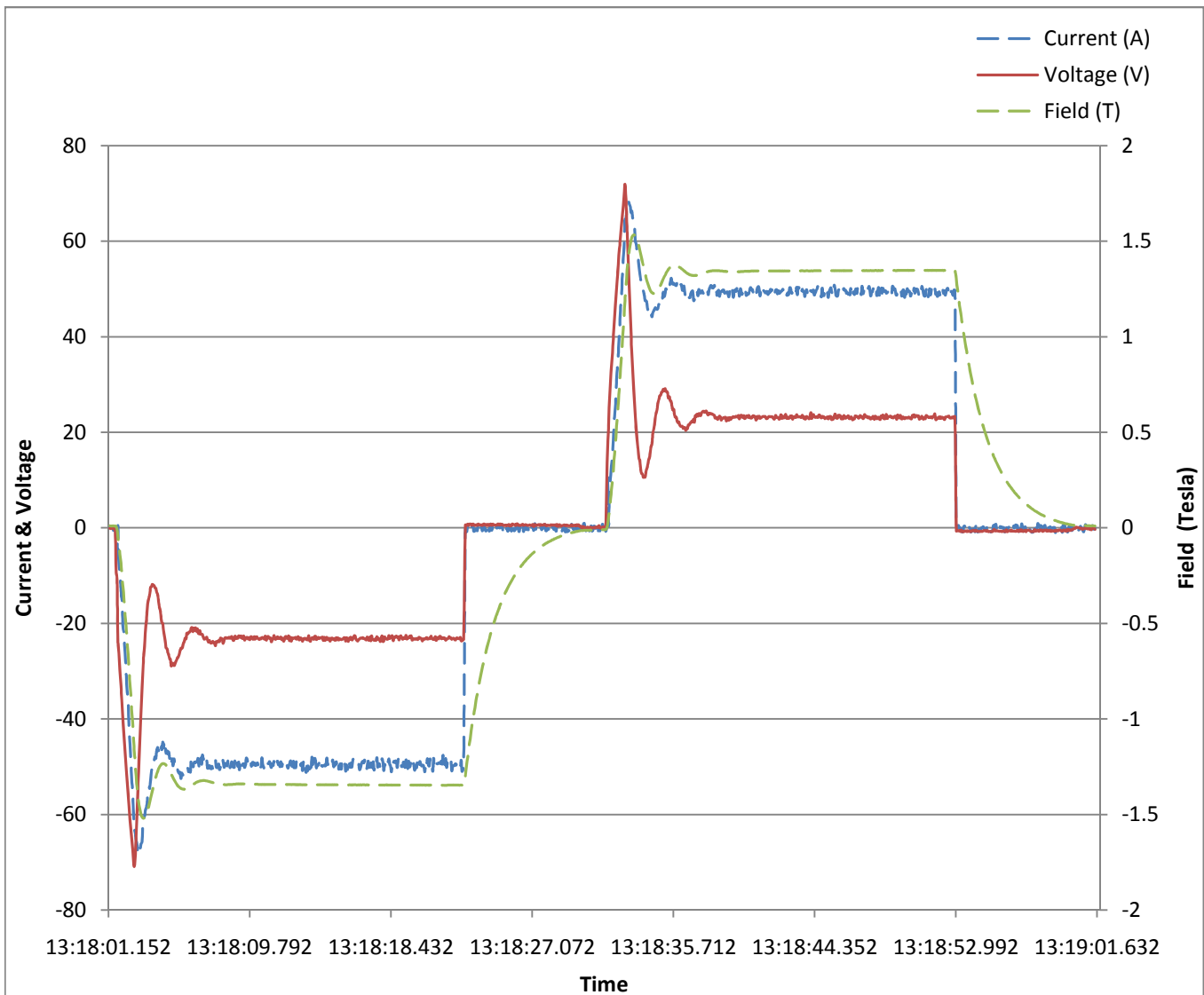
Pole: 50mm

Gap: 30mm

Field Meter: Senis YM12-5-5-5T

Serial No: 24-07

Note: Set Current: 50A, Timed Switching every 30 seconds.



GMW Associates

5971-160 Reversing Switch Performance Plot

Contract No: 9625

Page: 1 of 1

Date: 2 Dec, 2010

Customer: Army Research Lab

Engr: M. Duffy

5971-160 Serial No: 02

Power Supply: P83C-100150

Serial No: 0250A00730

Magnet Model: 3474

Serial No: 105

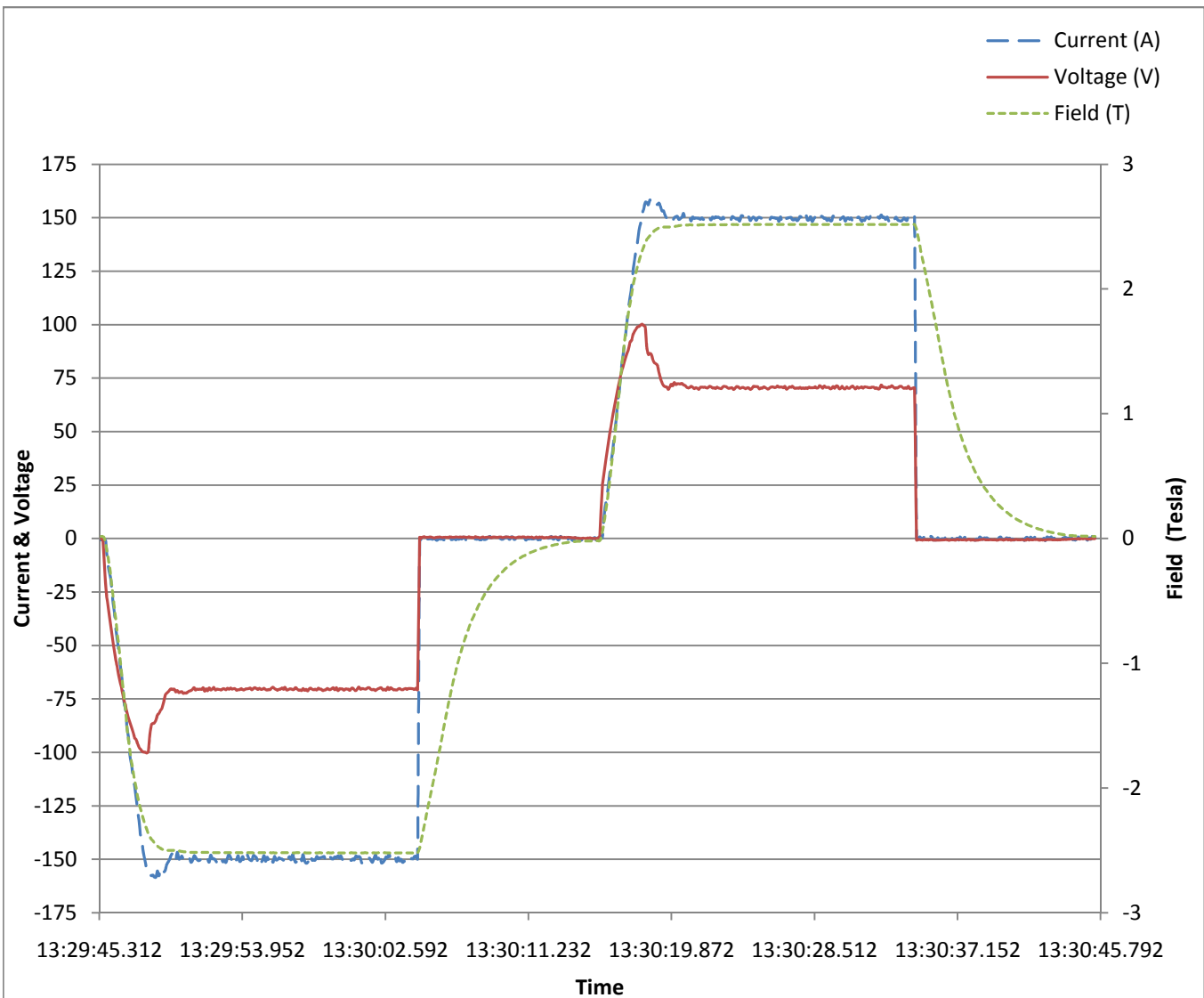
Pole: 50mm

Gap: 30mm

Field Meter: Senis YM12-5-5-T

Serial No: 24-07

Note: Set Current: 150A, Timed Switching every 30 seconds.



GMW Associates

5971-160 Reversing Switch Performance Plot

Contract No: 9625

Page: 1 of 1

Date: 7 Dec, 2010

Customer: Army Research Lab

Engr: M. Duffy

5971-160 Serial No: 02

Power Supply: P83C-100150

Serial No: 0250A00730

Magnet Model: 3473

Serial No: 153

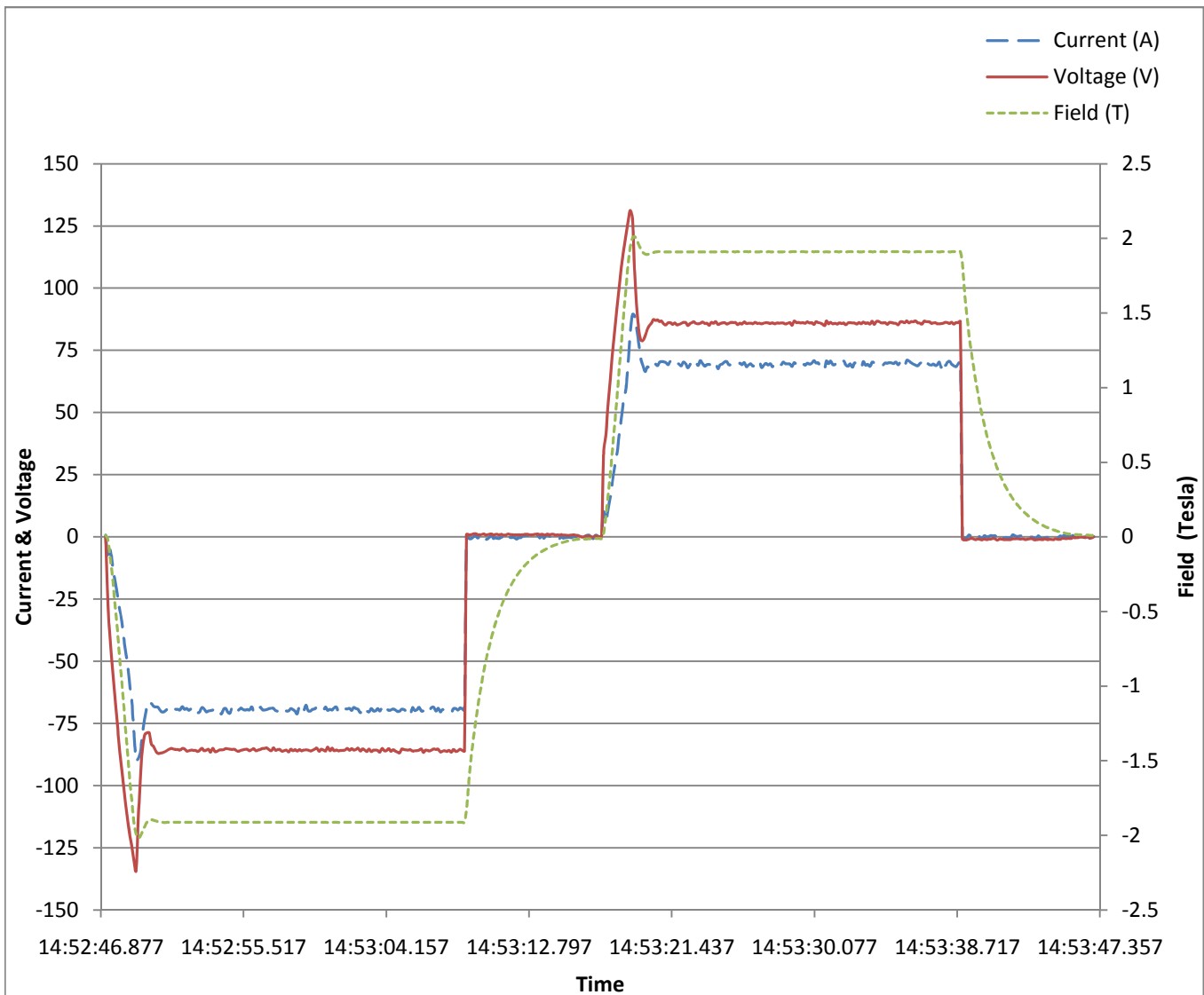
Pole: 100mm

Gap: 25mm

Field Meter: Senis YM12-5-5-5T

Serial No: 24-07

Note: Set Current: 70A, Timed Switching every 30 seconds.



GMW Associates

5971-160 Reversing Switch Performance Plot

Contract No: 9625

Page: 1 of 1

Date: 7 Dec, 2010

Customer: Army Research Lab

Engr: M. Duffy

5971-160 Serial No: 02

Power Supply: P83C-100150

Serial No: 0250A00730

Magnet Model: 5403

Serial No: 352

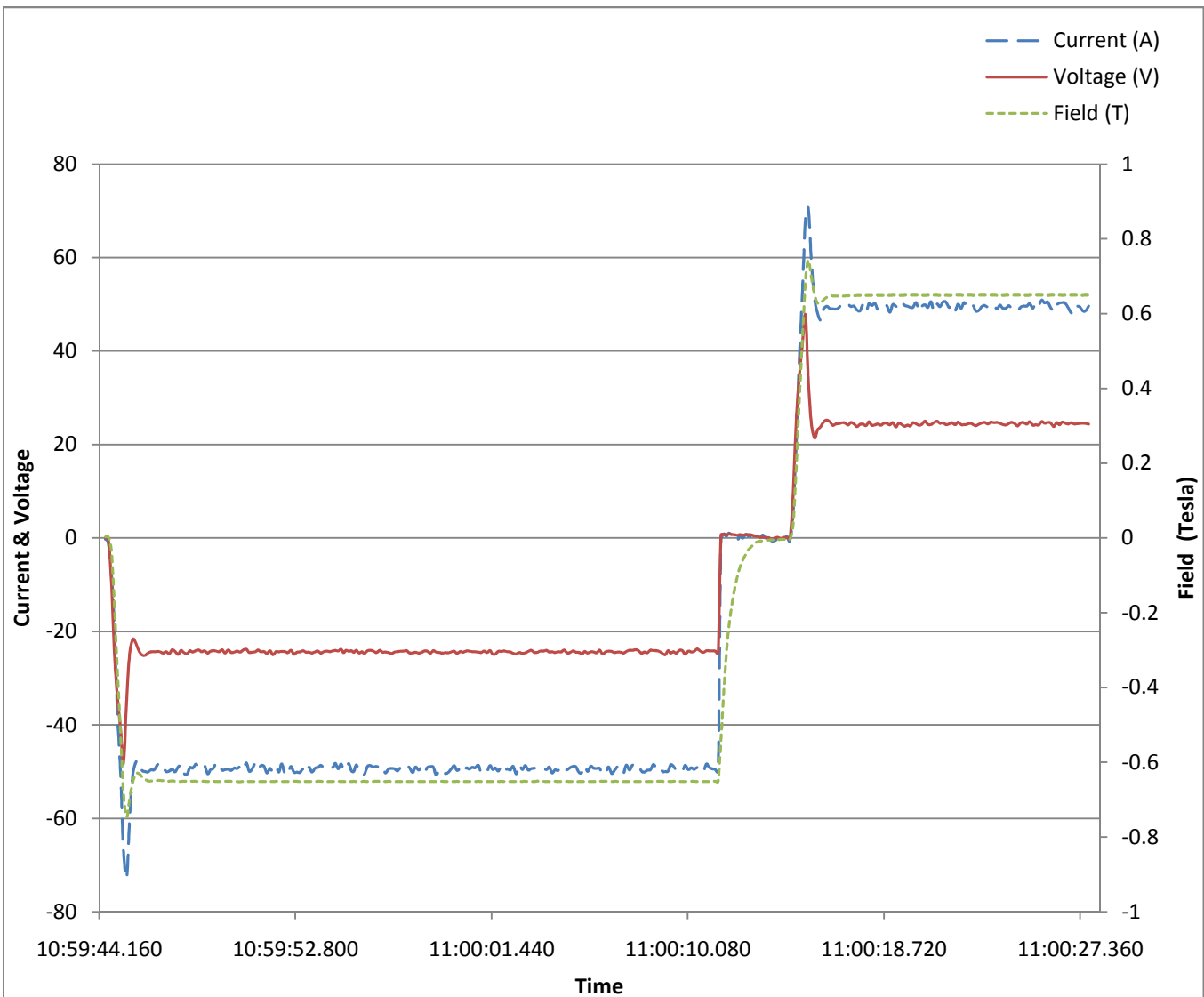
Pole: 76mm

Gap: 54mm

Field Meter: Senis YM12-5-5-5T

Serial No: 24-07

Note: Set Current: 50A, Timed Switching every 30 seconds.





LABORATORY ELECTROMAGNET SYSTEMS

WARRANTY DECEMBER 2010

GMW Associates warrants that all Electromagnets, Laboratory Electromagnet Systems and Electromagnet System Components supplied by GMW Associates will be free of defects in materials or workmanship for a period of 12 months from the date of installation or 15 months from the date of shipment whichever is the shorter.

Within this period GMW Associates will repair or replace defective parts free of charge either at the end user's site or at GMW Associates location at GMW choice.

GMW Associates will reimburse or pay the lowest two way freight charges on items returned to GMW Associates or our authorized agent provided prior authorization for shipment has been given by GMW Associates.

This warranty shall not apply to any equipment which our inspection shows to have become defective due to mishandling, misuse, improper maintenance or any other damage not generally acceptable for equipment of a similar type.

GMW Associates reserves the right to make changes in product or system design without incurring any obligation to modify previously delivered equipment.

The foregoing is the full extent of the GMW Associates warranty. No other warranty is expressed or implied. In no event shall GMW Associates be liable for damage arising from late delivery or misuse of the equipment. GMW Associates makes no warranty of the fitness of the equipment for the intended end-use other than the equipment meets the written specifications presented to the purchaser by GMW Associates.

If any defect or fault in the equipment is discovered the end-user should notify GMW Associates of the problem including details of Model numbers and serial numbers. GMW Associates will either make arrangements for service by the end-user or GMW Associates, or give authorization for return shipment to GMW Associates.

All return shipments must be made according to GMW Associates instructions with adequate packaging and documentation identifying the shipment including the GMW Associates Return Material Authorization (RMA) number. GMW Associates will not accept responsibility for equipment damaged in return shipment and thus all shipments should be properly packed and adequately insured by the customer.